

In the Drawings:

Please replace the first original sheet (1 of 2) of drawings with the enclosed revised Replacement Sheet bearing Figs. 1 and 2. In Fig. 2, the lead line of reference number 13b has been lengthened to reach the vertical force component, according to the specification at page 7 line 3.

[RESPONSE CONTINUES ON NEXT PAGE]

REMARKS:

- 1) The Examiner's attention is directed to applicant's second Information Disclosure Statement being filed together with the present Response. Please consider the references and return an initialed, signed and dated acknowledgment copy of the IDS Form PTO-1449 of March 5, 2008.
- 2) The Examiner's attention is directed to the enclosed Drawing Transmittal and one Replacement Sheet of drawings. See the above Drawing Amendment section. Entry of the revised Replacement Sheet is respectfully requested. Please indicate the acceptance of the drawings in the next official communication.
- 3) The specification has been amended editorially and to clarify certain inventive features in conformance with the original disclosure including the written description, claims and drawings. Also, the Summary of the Invention has been updated to conform to the present independent claims. The present amendments do not introduce any new matter. Entry thereof is respectfully requested.
- 4) The claims have been amended as follows. All prior claims 1 to 16 have been canceled. New claims 17 to 33 have been introduced. In accordance with the PCT procedures, the original claims of this national phase application were a direct literal translation of the foreign-language claims of the PCT international application. The present new claims have been drafted from the

ground up in a more-typical US claim style and form, to cover inventive subject matter in conformance with US practice, in comparison to the original translated PCT claims. The new claims are supported by the original disclosure as shown in the following table and do not introduce any new matter. Entry and consideration thereof are respectfully requested.

new claims	17	18	19	20	21	22	23	24	25
original support	cl 1; pg 2 ln 1-3; pg 3 ln 4-8; pg 6 ln 4-21	cl 2	cl 8	cl 8	cl 10	cl 9	cl 8	cl 10	cl 11

new claims	26	27	28	29	30	31	32	33
original support	cl 1, 9	cl 1	cl 1	Fig. 2	cl 1	pg 6 ln 14 - 19	Fig. 1 pg 4 ln 13-17	cl 1; Fig. 1; pg.4 ln 13-17

- 5) Referring to the top of page 2 of the Office Action, the objection to claim 12 has been obviated by the cancellation of claim 12. Also, the particular embodiment of a bi-axial acceleration sensor consisting of exactly two individual sensors is no longer being expressly pursued as a limitation in the new claims. Thus, please withdraw the objection.

- 6) Referring to the middle of page 2 of the Office Action, the objection to the drawings has been obviated by the cancellation of claim 12, without expressly reciting the subject matter thereof in the new claims. Thus, the drawings no longer need to be supplemented. Please withdraw the objection to the drawings.

7) Before particularly addressing the rejections and comparing the claimed features of the invention to the disclosures of the prior art, the invention will first be discussed in general terms to provide a background.

The present invention is directed to an acceleration sensor arrangement including plural inertial masses that are each respectively suspended in a frame in a pivotable manner by a respective set of two torsion spring elements. The two torsion spring elements are aligned with one another to form a respective torsional pivot axis of the respective inertial mass. Furthermore, each inertial mass is asymmetrical so that the center of gravity thereof is offset from the torsional pivot axis in two directions. Namely, the center of gravity is offset by a first offset distance (b) from a reference plane passing through the pivot axis, and is offset by a second offset distance (a) from a second plane that extends perpendicular to the reference plane along the torsional pivot axis of the inertial mass. In this regard, see Fig. 2 showing the offset distances (a, b) and see the specification at page 2 lines 1 to 3, page 3 lines 4 to 8, and page 6 lines 4 to 21.

Further particularly, in one embodiment of the invention, each inertial mass is configured and arranged in such a manner so that the ratio of the first offset distance (b) to the second offset distance (a) defines the trigonometric tangent function of an error angle or offset angle ϕ ; namely $\tan \phi = b/a$, such that the offset angle (ϕ) is greater than 20 degrees. See Fig. 2 and the specification at page 2 lines 1 to 3, page 3 lines 4 to 8, and page 6 lines 4 to 21.

The above mentioned features of the inventive sensor arrangement enable the sensor arrangement to be sensitive in all three orthogonal spacial directions, namely sensitive to accelerations along three orthogonal axes, and allow a greater angular pivoting deflection of each inertial mass. Namely, by pivoting about a pivot axis defined by the two torsion spring elements rather than bending along a bending beam support, the amount of vertical spacial deflection for a given angular deflection is reduced. This allows the device to be more compact and/or to achieve greater angular pivoting deflections.

More importantly, the configuration of each inertial mass to achieve the offset angle (ϕ) greater than 20° means that the ratio (b/a) of the first offset distance (b) to the second offset distance (a) must be greater than 0.36397 (i.e. $\tan 20^\circ = 0.36397$). In other words, using the definition of X, Y, Z directions shown in Fig. 2 of the present application, the offset distance (b) in the Z-direction must be greater than 0.36397 times the offset distance (a) in the X-direction. Compared to b/a ratios less than 0.36397, the inventive arrangement increases the sensitivity of the inertial mass to acceleration forces in the X-direction (for the arrangement in the present Fig. 2). This is achieved by configuring the inertial mass not as a vertically-thin paddle, but rather as a vertically-thick substantially-cubical block that is suspended near its upper surface by the torsion spring elements (see Fig. 2). That makes the inertial mass (in the arrangement of Fig. 2) sensitive to acceleration forces both in the Z-direction as well as the X-direction. In fact, this ratio of the offset distances (b/a)

can be adjusted to an ideal 1:1 relationship with the error or offset angle (ϕ) being 45° (see page 6 lines 4 to 21). Thereby, the sensitivity in the Z-direction and the sensitivity in the X-direction are equal to one another.

Another embodiment of the invention is directed to the interaction and arrangement of the supporting frame and the torsion spring elements connecting the inertial masses thereto. As shown in present Fig. 1, the overall supporting frame includes an outer frame (5) around the outer perimeter of the device, and an inner dividing frame (6) that divides the space within the outer frame into plural cells. Each respective inertial mass is supported by two torsion spring elements that connect the respective inertial mass to the outer frame on the one hand and to the inner dividing frame on the other hand. Namely, one torsion spring element connects the inertial mass to the outer frame, and one torsion spring element connects the inertial mass to the inner dividing frame. This is a robust, space-efficient, and compact structure that is also easy to fabricate (see present Fig. 1 and the specification at page 4 lines 14 to 17, page 5 lines 10 to 12).

The prior art does not disclose and would not have suggested the present inventive combinations of features and the advantages achieved thereby.

- 8) Referring to pages 3 to 5 of the Office Action, the rejection of claims 1, 2 and 12 as obvious over US Patent 6,122,965 (Seidel et al.) in view of US Patent 4,699,006 (Boxenhorn) is

respectfully traversed. This rejection will be discussed in connection with the new independent claims 17 and 33.

Claim 17 is directed to an acceleration sensor arrangement including plural inertial masses that are each respectively pivotably suspended by two torsion spring elements from a supporting frame. Each one of the inertial masses is asymmetrical so that a center of gravity thereof is offset by a first offset distance (b) from a reference plane and is offset by a second offset distance (a) from a second plane that extends perpendicular to the reference plane along a torsional pivot axis formed by the two torsion spring elements. The reference plane extends through the torsional pivot axis parallel to a surface of the inertial mass at rest without deflection thereof. So, the center of gravity is offset from the torsional pivot axis in two directions (the Z and X directions in the arrangement of Fig. 2 for example). More particularly, the inertial mass is respectively configured and arranged so that the trigonometric tangent function of an offset angle (ϕ) is given by the ratio (b/a) of the first offset distance to the second offset distance, and the offset angle (ϕ) is greater than 20° . In other words, the offset distance ratio (b/a) is greater than 0.36397 (given by $\tan 20^\circ$). This combination of structural features of the inventive arrangement achieves advantages that have been discussed generally above. The prior art does not disclose and would not have suggested such a combination of features or the advantages thereof.

Seidel et al. disclose an acceleration sensor arrangement having plural inertial masses that are each respectively in the

form of a thin cantilevered paddle connected by a bending beam to an outer frame (see abstract, Figs. 1 and 2). Seidel et al. do not disclose and would not have suggested a suspension by torsion spring elements rather than by bending beams. As discussed above, the use of torsion spring elements allows for a greater angular range of pivoting with a smaller vertical deflection in comparison to the use of bending beams. Seidel et al. absolutely require the use of bending beams (col. 1 lines 34 to 38 and col 2 lines 20 to 23) especially because the deflection sensors necessary for sensing the deflection of the cantilevered paddles are embodied as piezoresistors arranged directly on the bending beams (col. 2 lines 47 to 54). Such a deflection transducer arrangement can only function in connection with bending beams for the supporting suspension. Thus, a person of ordinary skill in the art would not have been motivated to provide torsion spring elements rather than bending beams for the suspension of the paddles.

Furthermore, Seidel et al. require the inertial masses to be configured as thin paddles, because they are simply formed by cutting-out or structuring a silicon wafer (10) using an etching process (col. 2 lines 55 to 67). As discussed in the present specification (see page 1 line 5 to page 2 line 3), such a paddle structure of the inertial masses as disclosed by Seidel et al. makes the inertial masses sensitive to acceleration forces predominantly in the Z-direction, because the so-called error angle (α) is between 10° and 20° (see col. 3 lines 9 to 19 of Seidel et al.). Thus, the sensitivity in the X-direction can be no more than 0.36397 ($\tan 20^\circ$) of the sensitivity in the

Z-direction. Contrary thereto, present claim 17 expressly recites that the offset angle (ϕ) is greater than 20° , which provides a higher sensitivity in the X-direction. That is achieved because the present inertial masses are not simply thin paddles cantilevered at one edge by a bending beam, but rather are thick boxy or substantially cubical inertial masses suspended from a position along the top surface by two torsion spring elements. So, the pivot axis is shifted from an edge of the inertial mass to a position within the top area of the inertial mass, and the inertial mass is made relatively thicker and more cubical in shape. That provides an offset angle (ϕ) greater than 20° , and a commensurate greater sensitivity in the X-direction. Such differences would not have been suggested by Seidel et al., because Seidel et al. expressly require thin paddle-shaped inertial masses suspended at an edge by a bending beam.

The Examiner has cited Boxenhorn for disclosing a suspension via two torsion spring elements. However, the acceleration sensor of Boxenhorn also seems to be sensitive only to one axis (Z) of acceleration force, so that a person of ordinary skill in the art would not have turned to the teachings of Boxenhorn when trying to construct or improve a multi-axial and especially tri-axial acceleration sensor (see col. 2 lines 25 to 36, col. 9 lines 15 to 49, and col. 10 lines 11 to 47).

The sensor according to Boxenhorn works on a significantly different principle than that of Seidel et al. Namely, in Seidel et al. the inertial masses are directly acted on by acceleration forces, and the deflection of the inertial masses is measured to determine the acceleration. On the other hand, in Boxenhorn the

sensor arrangement is actively driven to vibrate, and then an applied acceleration in the Z-direction shifts the inertial mass farther from the Y-axis, thereby changing the moment of inertia of the vibration about the Y-axis, so that a resultant change of the vibration frequency indicates the acceleration in the Z-direction. Thus, the teachings of Boxenhorn are not directly applicable to the different sensor arrangement of Seidel et al. There would have been no indication that the suspension by means of two torsion pivot spring elements according to Boxenhorn would have been suitable or useful in the sensor arrangement of Seidel et al. Namely, Seidel does not use active vibration and further features of Boxenhorn that are enabled by the particular suspension disclosed by Boxenhorn. Thus, a person of ordinary skill in the art would not have been motivated to combine the teachings of Boxenhorn with those of Seidel et al. in the manner as now proposed by the Examiner.

Furthermore, the teachings of Boxenhorn would not have led to a modification of Seidel et al. to make the error angle (α) greater than 20° . While Boxenhorn discloses an asymmetric inertial mass (Figs. 7 to 9), that inertial mass is used for an active vibration about the Y-axis with a resonant frequency which is shifted when an acceleration is applied in the Z-direction. Such features have nothing to do with the passive or direct deflection of inertial masses by acceleration forces in the acceleration sensor arrangement according to Seidel et al. Thus, the teachings regarding an asymmetric inertial mass of Boxenhorn would not have provided an apparent purpose or benefit in the structure according to Seidel et al.

Still further, even if the teachings of Boxenhorn had been considered for modifying the structure of Seidel et al., there still would have been no particular teaching or suggestion to increase the error angle (α) to be greater than 20°. Boxenhorn does not aim to provide an inertial mass that is directly sensitive to accelerations in two directions (for example X and Z directions), but rather the sensor arrangement is intended to be sensitive only to accelerations in the Z-direction as discussed above. Thus there would have been no suggestion to make the inertial mass more sensitive to accelerations in a direction orthogonal to Z, because that was not an intended goal of Boxenhorn.

Present independent claim 33 is directed to an acceleration sensor arrangement in which plural inertial masses are each respectively suspended by two torsion spring elements from a frame. The frame includes an outer perimeter frame and an inner dividing frame (for example see present Fig. 1). Each one of the inertial masses is suspended by one torsion spring element from the outer frame and by the other torsion spring element from the inner dividing frame. The references do not disclose and would not have suggested such a structure.

The frame arrangement of Seidel et al. includes an outer frame and an inner dividing frame, but the inertial masses are suspended exclusively from the outer frame via the bending beams. Such a bending beam support is required in order to achieve deflection sensing by piezoresistors as discussed above. There would have been no suggestion to suspend each inertial mass from both the outer frame and the inner dividing frame, because in the

construction of Seidel et al. that would have rendered the inertial mass immobile, i.e. non-deflectable.

The construction disclosed by Boxenhorn includes two levels of nested frames, with the inertial mass suspended by torsion springs from the inner frame, which in turn is supported by further torsion springs from the outer frame. There is no suggestion that each inertial mass shall be suspended by one torsion spring from the outer frame and by another torsion spring from an inner dividing frame. Thus, even a combined consideration of the two references would not have suggested the features of present claim 33.

The new dependent claims 18 to 32 depending from claim 17 recite additional features that further distinguish the invention over the prior art. The Examiner is respectfully requested to compare each of the dependent claims with the prior art.

For the above reasons, the Examiner is respectfully requested to withdraw the obviousness rejection applying Seidel et al. in view of Boxenhorn.

- 9) Referring to pages 5 and 6 of the Office Action, the rejection of claims 8 and 13 as obvious over Seidel et al. in view of Boxenhorn and further in view of US Patent 6,469,909 (Simmons) is respectfully traversed. The subject matter of prior claim 8 is now recited in present new claim 23 (and related subject matter is recited in new claims 19 and 20). Claim 23 depends from claim 18, which has been discussed above in comparison to Seidel et al. in view of Boxenhorn. The Examiner has additionally cited Simmons with regard to providing upper and

lower cover discs. The combination of features now proposed by the Examiner would not have been functional. Namely, the enclosed and hermetically sealed package provided by Simmons does not provide the gaps between the enclosed micromechanical device and the cover plates as required for operation of the micromechanical sensor assembly of Seidel et al. and Boxenhorn. Namely, the sensor arrangement of Seidel et al. must have gaps above and below the inertial masses to allow the inertial masses to deflect. Contrary thereto, it appears that the cover arrangement of Simmons does not provide such gaps both above and below the micromechanical device (e.g. see Figs. 11 to 17 and 22 of Simmons). Therefore, even a combined consideration of the references would not have made the present invention obvious. The Examiner is respectfully requested to withdraw the obviousness rejection applying Seidel et al., Boxenhorn and Simmons.

- 10) Referring to pages 6 to 8 of the Office Action, the rejection of claims 9 to 11 and 14 to 16 as obvious over Seidel et al. in view of Boxenhorn and further in view of US Patent 5,905,203 (Flach et al.) is respectfully traversed. The pertinent new claims 21, 22, 24 and 25 depend from claim 17, which has been discussed above in comparison to Seidel et al. and Boxenhorn. The Examiner has further cited Flach et al. for disclosing a differential capacitance measurement to determine the deflection of an inertial mass in an acceleration sensor. Nonetheless, the features of independent claim 17 discussed above would not have been suggested. For example, compared to present claim 17, the

disclosure of Flach et al. considered in combination with Seidel et al. and Boxenhorn would not have suggested that the error angle (α) of Seidel et al. should be increased to greater than 20°. Namely, in Flach et al. just as in Seidel et al., the inertial mass is a flat paddle formed by cutting-out or structuring a wafer by etching (see Figs. 7 and 8, col. 2 lines 20 to 67, and col. 3 lines 18 to 28). Thus, even considering the disclosures of the references in combination, a person of ordinary skill in the art would still have fabricated the inertial mass as a flat paddle or flat rocker simply cut out of a thin wafer. Furthermore, according to Flach et al., the center of gravity is not shifted away from the reference plane of the pivot axis in the vertical direction, but rather only in the horizontal lateral direction (see Fig. 7). Such teachings would have been directly contrary to increasing the offset angle in order to achieve a sensitivity on the vertical axis as well as an orthogonal horizontal axis.

Compared to present new independent claim 33, the sensor arrangement according to Flach et al. only includes a single inertial mass surrounded by a single outer frame. The inertial mass is supported by two torsion springs that both connect the inertial mass to the outer frame. There is no inner dividing frame, and there is no suggestion to connect one of the torsion springs to such an inner dividing frame. The teachings regarding the torsion springs do not involve a connection of the torsion springs to an inner dividing frame. Thus, such a connection and arrangement would not have been obvious even when considering the Flach et al. disclosure in combination with the other references.

Seidel et al. do not teach anything about the arrangement or connection of torsion springs, and Boxenhorn discloses that two torsion springs shall both connect the inertial mass to a common inner frame. So, when considering Flach et al. in combination with Boxenhorn, the only teachings are to connect the two torsion springs from the inertial mass to a common single frame surrounding the inertial mass, and there would have been no suggestion to connect one torsion spring to an outer perimeter frame and one torsion spring to an inner dividing frame.

For the above reasons, please withdraw the obviousness rejection applying Seidel et al. in view of Boxenhorn and Flach et al.

11) Favorable reconsideration and allowance of the application, including all present claims 17 to 33, are respectfully requested.

Respectfully submitted,
Konrad KAPSER et al.
Applicant

WFF:he/4814
Enclosures:
Transmittal Cover Sheet
Term Extension Request
Form PTO-2038
IDS w. Form PTO-1449
7 references
4 Engl. abstracts
Drawing Transmittal w.
1 Replacement Sheet
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